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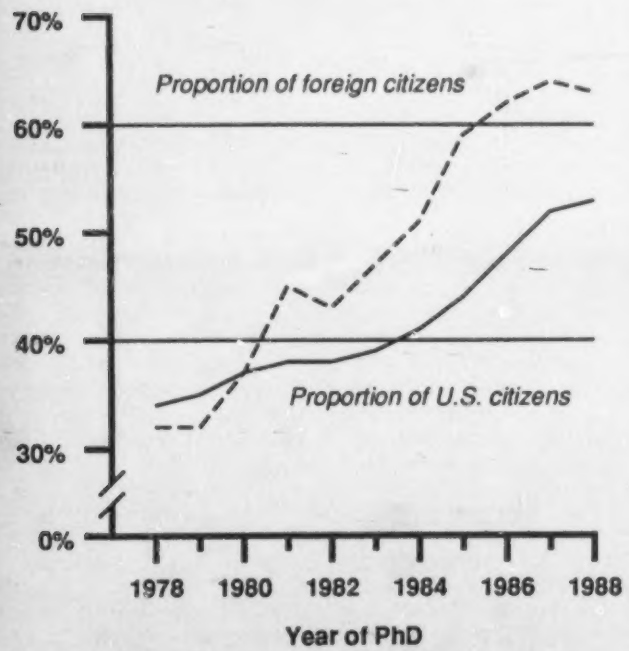
1987–88
GRADUATE STUDENT SURVEY

Since 1980, amid favorable predictions as well as words of caution, some twenty five thousand American graduate students decided on a career in physics by entering graduate physics programs all over the U.S. Most of these students will have based those career decisions on the opportunities and challenges they perceived their chosen career to offer them. During that same time period an additional ten thousand foreign students entered the United States with similar career goals but whose native countries, by and large, expect them to return home upon completion of their physics doctorates and help educate future generations of scientists abroad.

Figure I. Doctoral graduates who accepted 'postdocs,' 1978 to 1988.



Note: Each point on this graph represents a three-year average.

The Graduate Student Survey contacts all graduate physics and astronomy students with the request that each student contribute information on his or her educational background, the current student status, choice of subfield and employment prospects where applicable. Highlights of this report are:

- Physics departments offer support to 85% of their graduate students.
- Both U.S. and foreign physics doctorate recipients chose 'postdocs' in increasing proportions since 1979.
- Measured in terms of job offers, the experimentalists are in greater demand than the theoreticians.

By most definitions it is the completion of a doctorate that transforms a graduate student into a new physicist. But before discussing the detailed statistics associated with such a transformation in the most recent academic year, let us enumerate three ways in which doctoral graduates can begin their employment and elaborate on the choice selected by the majority of the doctorate recipients since 1986. The three choices are: (1) accepting a postdoctoral fellowship in the U.S., (2) preferring a position with potential permanence that may involve up to six months of looking and comparing offers or (3) leaving the U.S. The temporary 'postdocs' have been in abundance for almost 20 years and have been offered to doctorate recipients irrespective of their citizenship; but the availability of the alternatives to 'postdocs' differed significantly for U.S. and foreign graduates. Since very few foreign graduates are permanent residents in the United States, their major alternative to a 'postdoc' has been to return to their native countries. American graduates, on the other hand, have always had the option to choose potentially permanent employment in the U.S. To correct a widely-held assumption that the increase in 'postdocs' should be attributed only to the increase in foreign doctorate recipients, we present **Figure I** which divides the graduates on the basis of citizenship and shows their separate increases over a ten-year period. Thus a twenty percentage-point rise is indicated for U.S. citizens who chose 'postdocs' as their initial employment between 1978 and 1988; similarly, a thirty percentage-point rise is seen for foreign citizens.

Table I. Characteristics of the graduate physics student population, 1987–88.

Characteristics		All graduate students	First-year graduate students	Degree recipients: Terminal masters	Degree recipients: Doctorate recipients
	*Total population:	13 143	3 274	698	1 150
	Number of respondents:	7 327	1 159	246	682
Sex	Female	14%	15%	*16%	*10%
	Male	86	85	84	90
Citizenship	U.S.	*60%	*59%	85%	62%
	Foreign	40	41	15	38
Physics in high school	Yes	93%	91%	90%	94%
	No	7	9	10	6
Major of bachelor's degree	Physics	86%	84%	84%	90%
	Mathematics	2	2	1	3
	Engineering	6	8	8	4
	Other phys. science	2	2	4	2
	Other	4	4	3	1
Type of bachelor's institution	PhD-granting	38%	35%	40%	44%
	MS-granting	9	7	14	6
	BS/BA-granting	16	20	32	14
	Foreign	37	38	14	36
Type of graduate institution*	PhD-granting	90%	84%	75%	100%
	MS-granting	10	16	25	-
	Public	69%	74%	81%	62%
	Private	31	26	19	38
Source of support	Teaching assistantship	32%	53%	33%	11%
	Research assistantship	44	15	24**	71
	Fellowship	8	9	3	8
	Employment (full-time)	8	9	30	2
	Family, savings, loan	4	7	6	3
	Other	4	7	4	5

* *These data were derived from the survey of Enrollments and Degrees.*
** *Includes 11% military.*

Table I presents seven characteristics of the total graduate physics student population as well as those of three subgroups, namely, the first-year students, the terminal masters and the doctorate recipients. Our annual survey of Enrollments and Degrees establishes the total population in each of these groups, forming a base for interpreting the responses to the Graduate Student Survey. The first two rows of **Table I** present these numbers.

Despite efforts to encourage more women to become physicists, their proportion among the graduate physics student population increases only very gradually; three percentage-points in five years. The proportion of foreign graduate students is levelling off, but more details on that group are presented later in this report.

The influx into physics from other disciplines at the graduate level is generally small as illustrated by the fourth characteristic of **Table I**. Students who transfer from engineering continue to form the largest group among the first-year graduate students and among the terminal masters. The sixth characteristic divides the graduate enrollment on the basis of public and private institutions in order to compare attrition rates. For example, only 26% of the first-year graduate students enroll in private institutions, but these institutions confer 38% of the total number of physics doctorates.

With the exception of evening programs, primarily aimed at master's degrees, the great majority of physics departments offer teaching assistantships to their beginning graduate students. After two years of graduate work students become sufficiently advanced to qualify as research assistants. Graduate students who take advantage of late afternoon and evening programs invariably support themselves through full-time off-campus employment. Using family funds or a student loan, are means that very few graduate physics students need to fall back on.

There has been a steady increase in respondents to this annual survey who identify themselves as members of a specific minority group. **Table II** lists the minority groups and divides the larger ones on the basis of citizenship. By treating the Asian Indians and Arabs as predominantly foreign, we find that the U.S. minority groups comprise less than 4% of the respondents to this survey. Other characteristics selected for inclusion in **Table II** indicate that foreign minorities are more likely to have taken physics in high school and

Table II. Characteristics of minority group physics students, 1987–88.

Characteristics		Black U.S.	Black Foreign	Native American Indian	Hispanic Puerto Rican	Hispanic Mexican American	Hispanic Other U.S.	Hispanic Other Foreign	Asian Indian	Oriental U.S.	Oriental Foreign	Arab
	Total number:	59	28	14	18	16	42	91	353	133	1 748	163
Sex	Female	14	6	4	1	1	5	12	88	20	283	15
	Male	45	22	10	17	15	37	79	265	113	1 465	148
Candidacy for:	TMS	24	–	2	1	3	4	4	25	18	101	15
	MS and PhD	31	26	9	17	13	31	75	303	91	1321	133
	PhD only	4	2	3	–	–	7	12	25	24	326	15
Student status	Full-time	48	28	11	15	14	36	81	345	123	1 690	152
	Part-time	11	–	3	3	2	6	10	8	10	58	11
Physics in high school	Yes	46	26	9	16	12	35	90	343	126	1 707	160
	No	13	2	5	2	4	7	1	10	7	41	3
Full-time equivalent years of graduate study	<1	15	6	2	2	3	5	3	33	30	256	14
	2	23	4	1	3	3	9	18	44	24	345	38
	3	4	5	3	1	3	8	12	77	25	349	20
	4	5	2	3	6	5	10	16	62	24	314	23
	5	1	4	2	3	1	5	19	54	16	252	23
	6	4	3	1	–	–	3	12	35	5	155	20
	>7	7	4	2	3	1	2	11	48	9	77	25
Major subfields	Astro./ geophysics	2	1	2	1	2	2	9	25	7	79	13
	Condensed matter	12	10	4	9	7	16	26	142	44	784	56
	Elect., atomic, molecular	3	1	2	2	1	2	6	16	9	138	15
	Elem. particles	2	–	1	1	–	7	16	55	20	144	20
	Nuclear	7	7	1	–	–	2	11	26	15	99	19
	Optics/lasers	12	1	1	2	2	2	3	14	9	118	9
Graduate degree recipients	TMS	16	2	2	–	2	2	6	26	30	46	12
	Doctorates	8	4	1	2	1	5	16	73	20	164	21

have a lower attrition rate in graduate school. The proportion of women among the different minority groups varies widely, but remains high for U.S. blacks and Asian Indians when compared with the 14% women shown in **Table I**. Comparisons among the minority groups are difficult because of the wide range in the number of respondents from each group.

The choice of physics as a career is usually accompanied by an interest in one of its subfields. Thus, an important classification of the graduate students is in terms of the major areas of concentration. **Table III** relates the physics subfields to nine levels of graduate study thereby making it possible to estimate the number of graduates in a given subfield who will seek employment within a year or two.

Table III. Number of graduate physics students, by subfield* and years of graduate study completed, 1987–88.

		Full-time equivalent years of graduate study								Total graduate students	
		< 1 yr.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	>9 yrs.	N	%
Distribution of students	N	3 274	2 730	2 100	1 820	1 560	1 030	300	179	150	13 143**	
	%	24.9	20.8	16.0	13.8	11.9	7.8	2.3	1.4	1.1		100%
Astrophysics		280	165	140	110	105	60	25	10	10	905	6.9
Bio/medical physics		120	100	95	65	35	25	10	5	5	460	3.5
Condensed matter		880	800	730	685	570	380	100	60	40	4 245	32.3
Electron, atomic, molecular		205	185	165	145	150	90	15	15	15	985	7.5
Elementary particles		380	370	255	230	230	130	45	25	15	1 680	12.8
Mathematical physics		178	120	135	105	70	55	15	7	10	695	5.3
Nuclear physics		260	230	155	115	110	90	45	20	15	1 040	7.9
Optics/lasers		255	210	105	105	75	50	20	10	10	840	6.4
Plasmas/fluids/chaos		145	145	115	100	100	75	20	10	15	725	5.5
Physics applications		173	150	55	65	40	20	5	2	5	515	3.9
Other subfields		398	255	150	95	75	55	–	15	10	1 053	8.0

* *The distribution of students in each subfield is based on 7327 respondents to this question.*

** *The total was derived from the survey of Enrollments and Degrees.*

Table IV. Sources of support for graduate physics students, by degree status, 1987–88.

Source of support		Candidates for: Terminal master's	Master's enroute to PhD	PhD after master's	PhD only	Total N	Total %
Teaching assistantship		33%	47%	23%	26%	4 200	32
Research assistantship		22	30	57	60	5 800	44
Fellowship		2	9	10	8	1 050	8
Foreign government		1	1	1	1	120	1
Family, savings, loan		7	6	2	2	523	4
Full-time employment		29	5	4	1	1 050	8
Other*		6	3	2	2	400	3
		100%	100%	100%	100%		
Estimated distribution of all graduate students	N	2 043	4 000	5 000	2 100	13 143**	
	%	16	30	38	16		100%

* *Other includes part-time employment.*
** *The total was derived from the survey of Enrollments and Degrees.*

The type of support offered to graduate students depends not only on the level of graduate study but also on the types of degrees these students are candidates for. **Table IV** lists six distinct sources of support and divides the scaled up graduate student population on the basis of intended degrees. For example, research assistantships, by and large, appear to be reserved for graduate students who have passed their qualifying exams and thus form the largest group in **Table IV**, "PhD candidates after the master's degree." On the other hand, graduate students enrolled in PhD programs that do not require a master's enroute, may be offered research assistantships as first-year students. Although 40% of the graduate physics students are foreign citizens, only a very small percentage of them receive financial support from their native countries.

Omitted from this year's version of **Table IV** is the support distribution by sex because there are no longer significant differences between the proportions of assistantships offered to women and men.

The normal pattern of graduate education in physics consists of two years of course work followed by three or four years of research in a subfield that leads to a doctoral dissertation. The intensive professional work, which usually starts in the third year of graduate school, is performed either on an experimental or a theoretical basis. An array of doctoral candidates grouped by type of research, physics subfield and level of graduate study, is presented in **Table V**. The ratio of experimentalists to theoreticians remains at 2:1.

Table V. Number* of advanced graduate physics students specializing in selected experimental or theoretical subfields by years of graduate study completed, 1987–88.

Physics subfield	Type of research	Full-time equivalent years of graduate study: 3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	>9 yrs.	Total N	Total % Exp.	Total % Theo.
Astrophysics	experimental	79	61	58	43	14	7	5	267	5.5	
	theoretical	59	44	53	30	12	1	5	204		8.9
Bio/medical	experimental	86	56	27	12	8	8	3	200	4.1	
Condensed matter	experimental	547	527	410	279	67	49	32	1 911	39.5	
	theoretical	185	152	141	77	17	9	8	589		25.6
Electron, atomic, molecular	experimental	141	111	117	67	13	16	9	474	9.8	
	theoretical	33	34	38	24	5	3	5	142		6.2
Elem. particles	experimental	194	139	164	110	33	21	11	672	13.9	
	theoretical	79	104	81	26	9	3	3	305		13.2
Math. physics	theoretical	139	111	77	61	13	8	11	420		18.3
Nuclear	experimental	114	89	62	70	32	16	13	396	8.2	
	theoretical	50	32	53	26	15	5	1	182		7.9
Optics/lasers	experimental	93	84	69	42	13	7	6	314	6.5	
Plasmas/ fluids/chaos	experimental	47	51	45	49	11	7	8	218	4.5	
	theoretical	44	49	56	28	13	4	8	202		8.8
Physics applications	experimental	49	35	20	17	4	3	5	133	2.7	
Other subfields	experimental	78	66	50	35	13	8	5	255	5.3	
	theoretical	83	75	39	34	8	4	12	255		11.1
Total	experimental	1 428	1 219	1 022	724	208	142	97	4 840	100.0%	
	theoretical	672	601	538	306	92	37	53	2 299		100.0%

* *The numbers in this table have been scaled up to reflect the total number of graduate students (7139) who completed three or more years of graduate study.*

Table VI. Distribution by subfield and employment offers for doctorate recipients, 1987–88.

Physics subfield		Total in subfield	New 'postdocs' in the U.S.	Employment-oriented graduates in the U.S.	Percentage of graduates seeking potentially permanent employment in the United States received: 0 offers	1 offer	>2 offers
Astrophysics		7.0%	4.5%	2.9%	12%	47%	41%
Chemical physics		2.5	2.2	0.3	–	50	50
Condensed matter		32.0	21.3	11.3	1	49	50
Electron, atomic, molecular		7.6	4.8	3.1	–	67	33
Elementary particles		14.2	9.8	4.1	8	58	34
Geophysics		2.6	1.5	0.9	20	80	–
Mathematical physics		6.7	4.3	2.4	14	72	14
Nuclear		10.0	6.2	3.6	14	43	43
Optics/lasers		4.3	1.5	2.7	–	56	44
Plasmas/fluids/chaos		6.5	4.3	1.7	–	60	40
All other subfields		6.6	4.2	2.4	–	57	43
Total	%	100.0%	64.6%	35.4%	5%	55%	40%
	N	1150	636*	359*			
All experimental subfields		64%	406	253	3%	46%	51%
All theoretical subfields		36%	230	106	10%	71%	19%

**An estimated 155 doctoral graduates, not part of the employment analysis, include 122 who leave the U.S. and 33 whose plans are described as "Other" in Figure III.*

DEGREE RECIPIENTS

In the United States the two types of initial employment available to new doctorate recipients are: postdoctoral fellowships and positions with potential permanence. The ratios in which new physicists make those choices depend as much on their dissertation subfields as on their citizenships. Foreign graduates are generally limited to postdoctoral fellowships because U.S. immigration laws permit only temporary employment on a student visa for work that is directly related to the area of study; the assumption the immigration service makes is that highly technical employment is not available in the graduate's native country. **Table VI** divides the dissertation subfields into ten major areas of concentration and, as its first column of data, presents the distribution of all 1150 doctorate recipients. The central portion of **Table VI** focuses on the estimated 995 doctoral graduates who remain in the U.S. and choose between two types of initial employment. The third part of this table singles out the subgroup interested in permanent positions and relates the job offers they received to the subfields of their dissertations.

The type of research is another characteristic that influences the demand for new physicists; hence the last two rows of **Table VI** distinguish between experimentalists and theoreticians. The proportion of job offers each group received clearly indicates that the experimentalists are in greater demand because a larger proportion of them received multiple offers to choose from, and only 3% (compared with 10% of the theoreticians) reported no offers at the time of the survey.

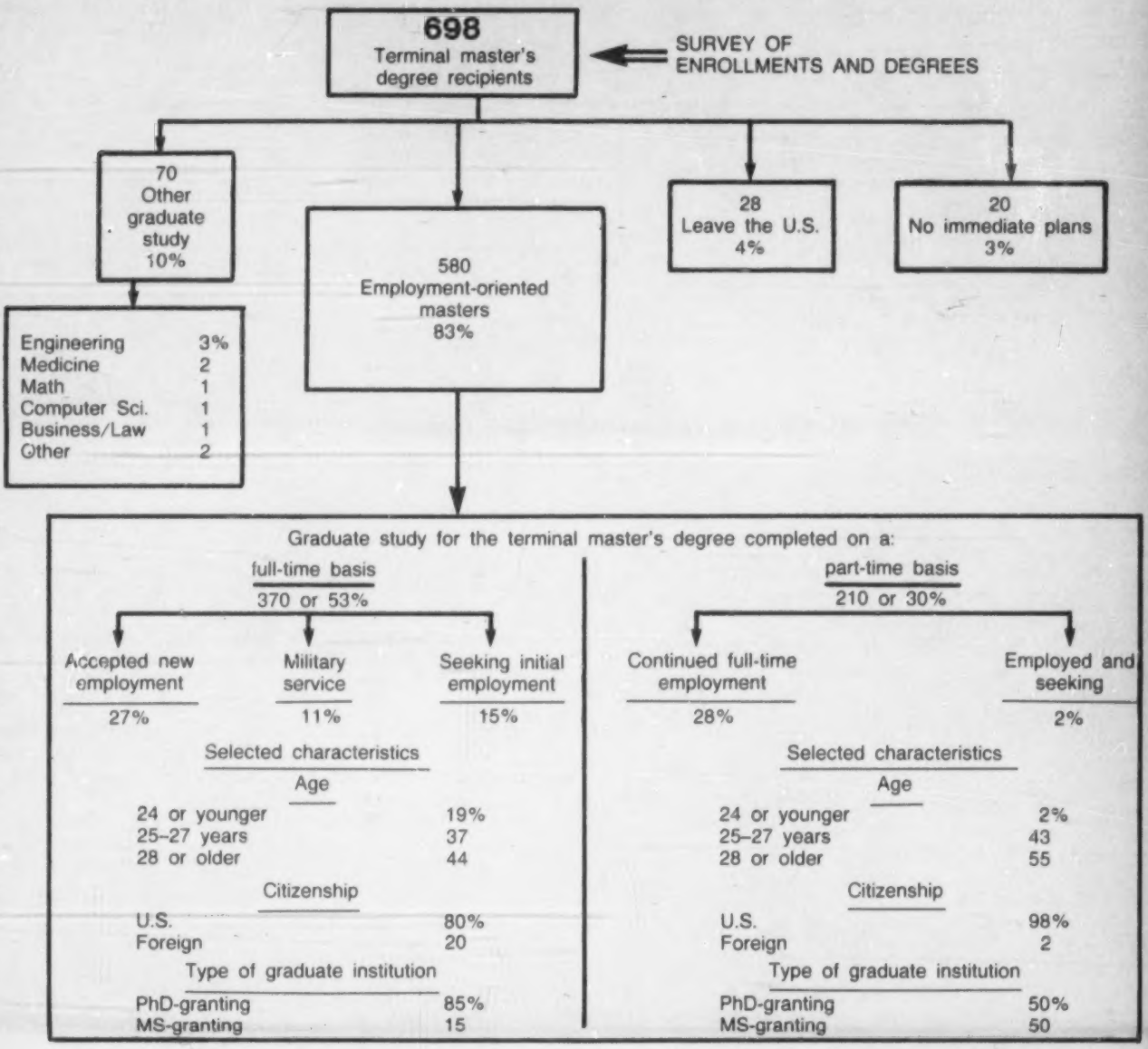
A more comprehensive view of the initial employment of doctoral physicists includes employment opportunities abroad as well as their citizenships. **Table VII**, based on 662 respondents, includes 252 foreign citizens, 14% of whom had secured potentially permanent positions in the U.S. Of a similar number of foreign graduates in the previous year only 10% fell into that category.

Table VII. Employment of doctoral graduates by citizenship, 1987–88.

Doctoral graduates		U.S. employer 'Postdoc'	U.S. employer Accepted	U.S. employer Cont.	Foreign employer 'Postdoc'	Foreign employer Accepted	Uncommitted in the U.S.	Total N	Total %
U.S. citizens		222	138	15	17	1	17	410	62
Foreign citizens		155	32	3	11	43	8	252	38
Total	N	377	170	18	28	44	25	662	
	%	57	26	3	4	7	4		100%

Note: Twelve graduates had no immediate plans and eight graduates reported "other graduate study."

Figure II. Post-degree plans of physics terminal master's degree recipients, 1987-88.



Although the study of physics provides a broad scientific background for a wide variety of careers, most of the undergraduate physics majors intend to become "physicists" and are aware that graduate training is an essential part of the preparation for that career. What is often not clear to them, is that they may have to commit six years to full-time graduate study. The terminal master's degree is a compromise between realizing that "graduate training is essential to becoming a physicist" and not wanting to commit the number of years required to complete a doctorate in physics. There is also a considerable degree of flexibility associated with studying for a terminal master's degree: the course-work can be handled on a full-time or part-time basis and at many universities a dissertation is optional.

Table VIII. Distribution of terminal masters by subfield and use of physics training, 1987–88.

Physics subfield	Total in subfield*	Post-degree use of subject matter reported by employed masters		
		extensive	little	none
Acoustics	10%	14%	86%	–
Astrophysics	5	20	60	20%
Condensed matter	18	65	26	9
Electron, atomic, molecular	7	50	40	10
Geophysics	6	20	80	–
Nuclear physics	12	21	79	–
Optics/lasers	12	55	45	–
Physics applications	10	45	55	–
All other subfields	20	67	33	–
Total	100%	43%	54%	3%

* *Based on 246 respondents.*

The annual number of terminal master's degrees granted during the past decade ranged between 600 and 700. Each year the degree recipients include a proportion of doctoral candidates who decide to accept a terminal master's degree after taking the qualifying examinations. **Figure II** highlights the class of 1988 both in terms of the approaches they used to acquire this degree as well as the different options these graduates pursued after becoming physics masters.

Only an estimated 10% of the masters used that physics training as background for further studies in another discipline. The large employment-oriented group includes approximately 200 masters who continued the full-time employment that supported them through graduate school. Those who completed their terminal master's degrees on a full-time basis, largely through assistantships from the physics departments, experienced some difficulty in finding initial employment. **Figure II** presents three characteristics of each of the two groups in order to show that the full-time students are younger, include a larger proportion of foreign graduates and enrolled primarily at doctorate-granting institutions.

For the majority of master's degree candidates the writing of a dissertation is optional; nevertheless, almost all our respondents identified a subfield they concentrated on during their graduate studies. **Table VIII** shows the extent to which the masters utilized their specialties in post-degree employment.

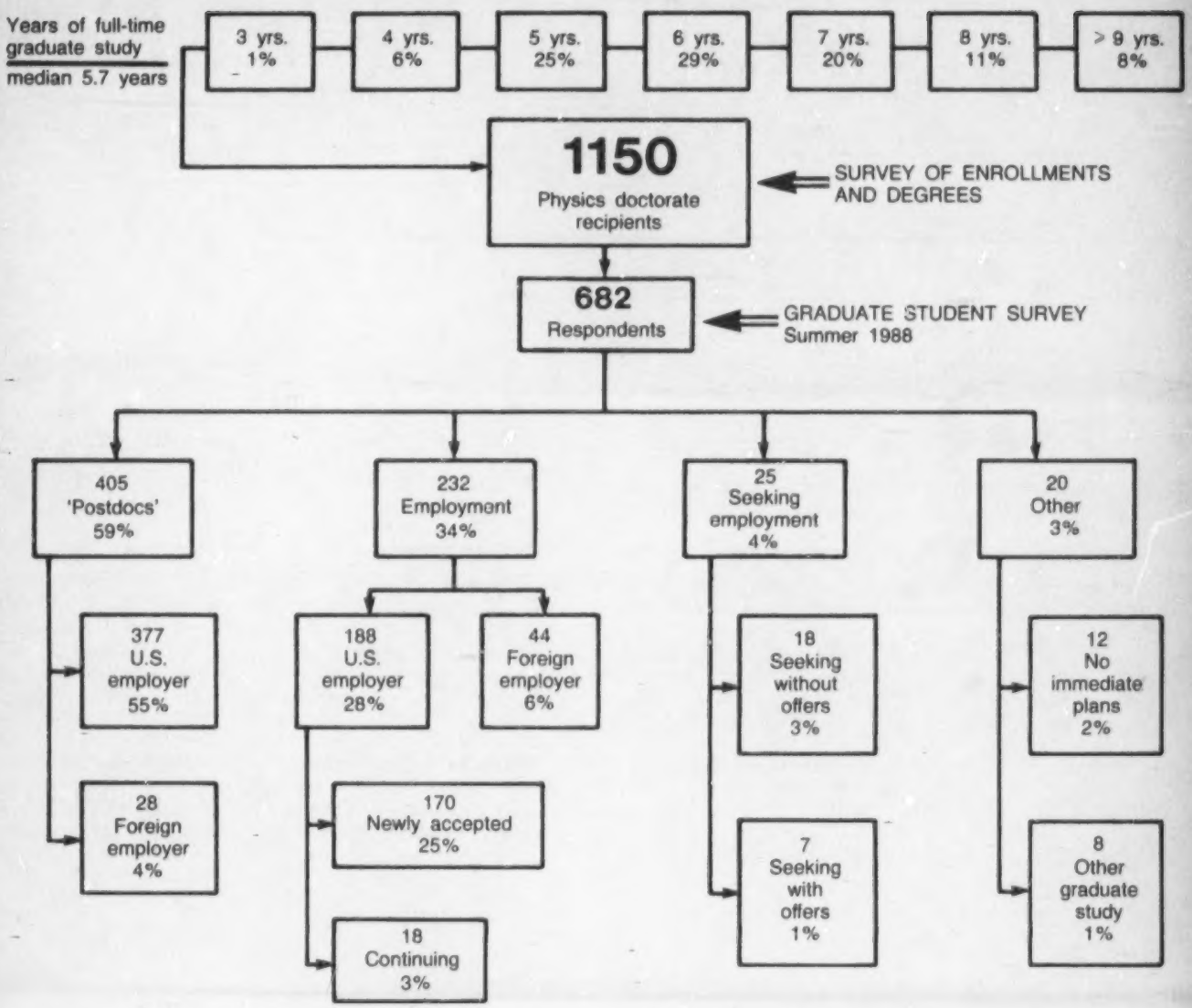
With only a master's degree very few graduates choose academic employment. As in past years industry remains the largest single employer where physics masters perform engineering tasks as well as research and development activities. **Table IX** links eight types of employers to the major work activities which include "nonphysics professional work" an area primarily chosen by the career military graduates.

Table IX. Employment characteristics of 1987–88 recipients of physics master's degrees.

Work activity	Type of employer								Total	
	University	College	Secondary school	Industry	Government	Military service	Fed. funded res. ctr.	Non-profit organization	N	%
Teaching	2	12	18	–	5	3	–	7	47	10
Research	5	–	–	12	15	–	12	–	44	9
Res. and dev.	7	2	–	60	30	15	15	2	131	28
Engineering	–	–	–	122	2	10	–	–	134	28
Comp. science	–	–	–	12	2	–	–	–	14	3
Consulting	–	–	–	11	–	–	–	–	11	2
Management	–	–	–	8	5	15	–	–	28	6
Nonphysics prof'l	–	–	–	10	7	35	–	14	66	14
Total N	14	14	18	235	66	78	37	23	475	
%	3	3	4	49	14	16	8	5		100%

Note: The data in this table are not comparable to those reported in earlier years because both individual degree recipients as well as department chairpersons were asked to contribute employment information.

Figure III. Post-degree plans of physics doctorate recipients, 1987-88.



From the trends shown in **Figure I**, we focus on a single academic year in **Figure III**. This figure in turn elaborates on the data presented in **Table VII** by relating the respondents to the total number of doctorates granted in 1987-88 and including information on the number of years expended in completing a physics PhD. Also included in this flow diagram is the group of graduates who have no immediate employment plans.

Table X. Use of physics in potentially permanent employment for graduate degree recipients, 1987–88.

	Major employer	Extensive use of physics training with respect to: Method	Subject matter	Number responding to question
Doctorate recipients	Univ./coll.	81%	86%	43
	Industry	90	64	69
	Fed. funded res. ctr.	92	62	13
	Government	71	71	24
	All employers	85%	71%	154

		Use of physics training with respect to subject matter: Extensive	Little	None	Number responding to question
Terminal masters	Educational inst.	72%	28%	–	18
	Industry	52	40	8%	50
	Fed funded. res. ctr./ gov't.	28	72	–	85
	All employers	41%	56%	3%	155

The increase in the median number of years of graduate study required to complete a physics doctorate, from 5.2 years in 1980, calls attention to the diversity of doctoral candidates at U.S. universities. On the one hand we have foreign students, some of whom enter at advanced levels of study; on the other hand, we find a wide range in quality among the undergraduate programs at U.S. colleges and universities, whose graduates require additional years of graduate study.

When accepting potentially permanent employment, the two groups of graduate degree recipients view the use of physics training differently. Doctorate recipients are concerned about working in their subfields as well as using the research methods they developed over several years. Terminal masters, who spend less time in graduate school, are primarily concerned about the extent to which they utilize the subject matter of their specialization. The two parts of **Table X** summarize the responses from 154 doctoral physicists and 155 terminal masters. The major types of employers are listed for both groups and, as expected, for each type of employer more doctoral physicists than terminal masters are making extensive use of the subject matter of their respective subfields.

Table VII indicated that 153 U.S. and 35 foreign doctoral graduates found potentially permanent employment in the U.S.; **Table XI** offers additional details on the employers and work activities they reported. In comparison with the previous year, the 1988 data indicate a shift away from industry and toward the two types of government laboratories.

Table XI. Employment with potential permanence in the U.S. for 1987–88 physics doctorate recipients.

Work activity		Type of employer: University	College	Industry	Fed. funded res. ctr.	Government	Other	Total N	Total %
Teaching		9	5	–	–	–	–	14	7
Research		7	–	14	11	11	3	46	25
Res. and teaching		21	12	–	–	1	–	34	18
Res. and dev.		–	–	48	5	15	2	70	37
Engineering		–	–	10	1	–	–	11	6
Mgt./consulting		–	–	4	1	1	–	6	3
Other		1	–	3	–	–	3	7	4
Total	N	38	17	79	18	28	8	188	
	%	20	9	42	10	15	4		100%

Table XII. Median monthly starting salaries paid by U.S. employers to new physics degree recipients, 1988.

Type of Employer	Bachelor's degree recipients		Terminal master's degree recipients		Doctorate recipients			
	Percentage accepting positions	Monthly starting salaries	Percentage accepting positions	Monthly starting salaries	Percentage accepting: 'Postdocs'	Percentage accepting: Potentially perm. pos.	Monthly starting sal. for: 'Postdocs'	Monthly starting sal. for: Potentially perm. pos.
Secondary school	5%	$1550	4%	•	–	–	–	–
College	1	1550	3	•	1%	3%	•	$2330
University	3	1700	3	$2050	50	6	$2070	2450
Industry	53	2210	49	2690	4	13	3400	3730
Gov't. inc. mil.	34	1715	30	2340	4	4	2650	3070
Fed. funded res. ctr.	3	2050	6	•	9	3	2430	•
Other	1	–	5	•	2	1	2030	•
All employers	100%	$1930	100%	$2600	100%		$2150	$3400

**Insufficient data.*

Starting salaries presented in **Table XII** include only those paid by U.S. employers for newly accepted positions. By adding the starting salaries of physics bachelors to this table, we are showing four salaries for three degree levels. The doctoral physicists are divided into two groups because those who accepted potentially permanent employment are paid significantly higher salaries than those starting postdoctoral fellowships. Until 1986, the median salary of 'postdocs' was lower than the bachelors' median salary: but a 13% increase over that three-year period places the 'postdocs' between the bachelors and the terminal masters. In each of the degree categories industry pays the highest salaries but fewer doctoral physicists accepted industrial offers with potential permanence. The median salary of $3400 did not change from the previous year.

ASTRONOMY

Since the doctoral astronomy departments offer acceptances into their graduate programs to only one in ten applicants, the resulting stable enrollment trend, since the early 1980s, must be deliberate. Consequently, comparisons with physics seem inappropriate. Also attrition among astronomy students tends to be low. For the academic year 1987-88, department chairs reported 731 graduate astronomy students and **Table XIII** links their level of graduate study to the major subfields they chose.

Table XIII. Graduate astronomy students* by subfield and years of graduate study, 1987–88.

		Full-time equivalent years of graduate study						Total	
		<1 yr.	2 yrs.	3 yrs.	4. yrs.	5 yrs.	>6 yrs.	N	%
Distribution of students	N	171	139	114	110	102	95	731	
	%	23%	19%	16%	15%	14%	13%		100%
Astronomy subfields									
Astronomical instruments and techniques		7%	6%	4%	7%	2%	4%	37	5%
Cosmology, extragalactic objects, quasi-stellar objects		19	22	28	46	21	27	190	26
Galactic structure, stellar motions		6	15	6	1	9	1	51	7
Interstellar matter and gaseous nebulae		11	10	14	14	19	21	102	14
Solar system, space astronomy of the solar system		5	8	3	3	4	11	44	6
Stellar atmospheres and spectra, stellar evolution, solar and stellar interiors		17	19	21	13	25	21	139	19
Supernovae, X, γ and cosmic rays, pulsars		5	8	5	1	3	7	37	5
The sun		3	2	–	–	3	5	15	2
Astrophysics		14	8	7	7	10	3	58	8
All other subfields combined		13	2	12	8	4	–	58	8
		100%	100%	100%	100%	100%	100%		

** The percentages shown in this table are based on 527 respondents to the Graduate Student Survey. Astronomy department chairpersons reported a total of 731 graduate students for the survey of Enrollments and Degrees.*

Table XIV. Characteristics of the graduate astronomy student population, 1987–88.

Characteristics		All graduate students	First-year graduate students	Terminal master's	Doctorate recipients
	*Total population:	731	171	24	94
	Number of respondents:	527	101	10	67
Sex	Female	18%	18%	*29%	*14%
	Male	82	82	71	86
Citizenship	U.S.	*77%	*74%	90%	69%
	Foreign	23	26	10	31
High school physics	Yes	90%	91%	80%	95%
	No	10	9	20	5
Major of bachelor's degree	Astronomy	37%	35%	50%	37%
	Physics	53	55	50	51
	Engineering	3	4	–	3
	Mathematics	2	2	–	3
	Other	5	4	–	6
Type of bachelor's institution	PhD-granting	58%	56%	40%	60%
	MS-granting	3	4	10	3
	BS/BA-granting	14	21	40	7
	Foreign	25	19	10	30
Type of graduate institution*	PhD-granting	95%	91%	79%	100%
	MS-granting	5	9	21	–
	Public	74%	70%	58%	72%
	Private	26	30	42	28
Source of support	Teaching assist.	30%	52%	40%	10%
	Research assist.	48	19	20	72
	Fellowship	13	20	–	12
	Family, savings, loans	4	7	10	3
	Foreign government	1	1	–	–
	Other	4	1	30	3
Major subfields	Cosmology	26%	19%	20%	27%
	Interstellar matter	14	11	10	18
	Solar system	6	5	–	5
	Stellar atmos. & spectra	19	17	20	18
	Astrophysics	8	14	10	10

* *These data were reported by astronomy department chairpersons as part of the survey of Enrollments and Degrees.*

Approximately half of the graduate astronomy students were physics majors as undergraduates because so few astronomy bachelor's degree programs are available. Eight characteristics of astronomy students and three subgroups, that include degree recipients, are presented in **Table XIV**. Since 1983, foreign students comprise one-quarter of the graduate astronomy enrollment.

Figure IV. Characteristics and post-doctorate status of 1987-88 astronomy graduates.

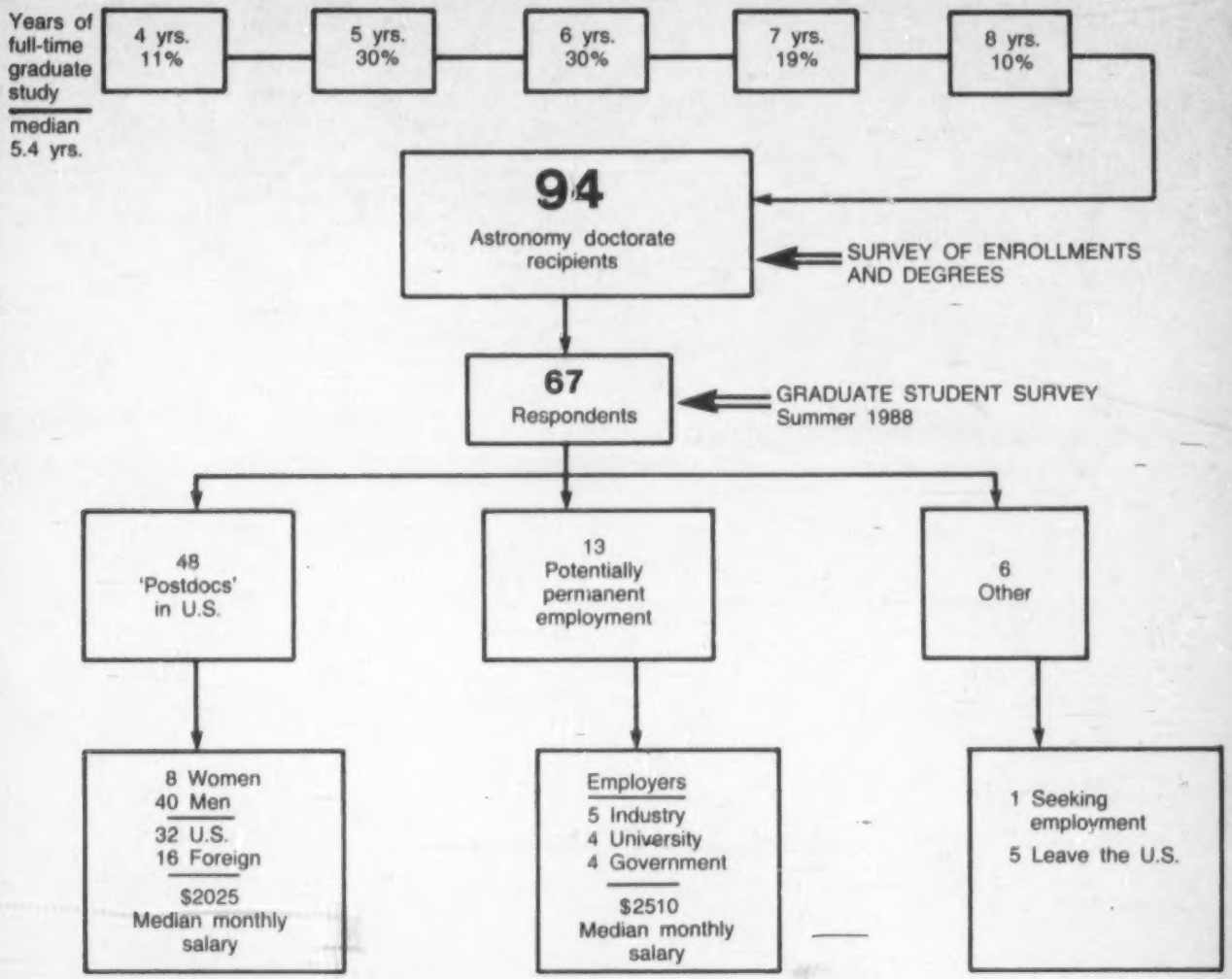


Figure IV elaborates on the characteristics of the new doctoral astronomers included in **Table XIV** by presenting their post-degree employment status. Following historical patterns, a majority of the new astronomers accepted 'postdocs' and the 1988 respondents in that group included eight of the nine women. The postdoctoral salary is very close to the $2070 universities offered to physics 'postdocs'. On the other hand, the median salary offered to new astronomers by the employers for potentially permanent positions is relatively low. Only one doctorate recipient was still seeking a position at the time of the survey.

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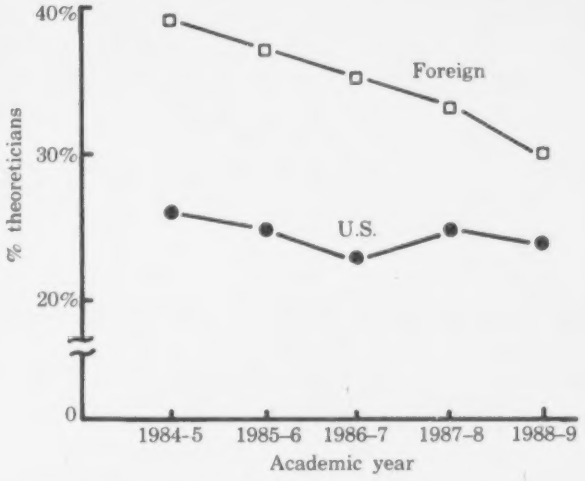
1988–89
GRADUATE STUDENT SURVEY

As the physics graduate student population reflects an increasingly international background, one cannot help but speculate about a further diversification that may come about as a result of an influx of students from a less restricted eastern Europe. The annual Graduate Student Survey has been monitoring major changes for the past three decades. This survey contacts all graduate physics and astronomy students with the request that each student contribute information on his or her educational background, the current study status, choice of a subfield and employment prospects where applicable. Highlights of this report are:

- Collectively, 16% of the foreign graduate physics students are women compared with 13% of the U.S. students.
- Almost half of the physics doctorate recipients who sought permanent employment reported multiple offers to choose from.
- An increasing proportion of the physics masters report that their initial employment makes extensive use of their training.

By the late 1980s, a graduate physics education was less likely to be counted among the services the United States exports because an increasing number of foreign degree recipients, from our graduate physics programs, intended to remain in this country at least for several years. A direct consequence of this changing trend was a shift in the type of research chosen by foreign doctoral candidates. Traditionally, the cultural backgrounds of many foreign students steered them toward a theoretical dissertation; however, the prospect of remaining in the U.S. obliged them to investigate the preferences of American employers whose emphasis on applied research corresponds to a greater demand for experimentalists than for theoreticians. **Figure I** focuses on the most recent five-year period during which the proportion of foreign theoreticians declined. Doctoral candidates in **Figure I** are defined as physics students who have completed four or more years of graduate study, a number that increased from 4500 to 5000 during that five-year period. The estimated number of theoreticians among the doctoral candidates decreased slightly from 1400 to 1350, but an analysis with respect to their citizenship reveals a relatively stable proportion of U.S. theoreticians while foreign theoreticians declined from 39% to 30%.

Figure I. Proportion of theoreticians among doctoral candidates,* by citizenship, 1984–1989.



**Physics students who have completed four or more years of graduate study.*

Anticipated findings as well as anomalies are brought to light by comparing the total graduate student population with three subgroups, namely, the first-year graduate students, the terminal masters and the doctorate recipients. The first of seven characteristics, presented on this basis in **Table I**, is sex where the comparison between the proportion of women among all graduate students and that among the first-year students hardly differ. From those percentages, one must conclude that the efforts to encourage more women to become physicists has not been successful so far. Re-enforcing this conclusion is the proportion of women among the doctoral recipients; it is six percentage-points below the 14% that women comprise of all graduate physics students. Though not included in this table, a further analysis would show that the U.S. contingent of all the graduate students includes only 13% women, whereas 16% women were recorded among the for-

Table I. Characteristics of the graduate physics student population, 1988–89.

Characteristics		All graduate students	First-year graduate students	Degree recipients: Terminal masters	Degree recipients: Doctorate recipients
	*Total population:	13 361	3 132	681	1 112
	Number of respondents:	7 391	1 329	275	708
Sex	Female	14%	15%	*16%	*8%
	Male	86	85	84	92
Citizenship	U.S.	*59%	*58%	82%	61%
	Foreign	41	42	18	39
Physics in high school	Yes	93%	91%	86%	95%
	No	7	9	14	5
Major of bachelor's degree	Physics	89%	87%	83%	89%
	Mathematics	2	3	—	3
	Engineering	6	7	9	6
	Other phys. science	2	2	3	1
	Other	1	1	5	1
Type of bachelor's institution	PhD-granting	39%	36%	38%	43%
	MS-granting	6	8	15	4
	BS/BA-granting	16	19	25	15
	Foreign	39	37	22	38
Type of graduate institution*	PhD-granting	90%	84%	75%	100%
	MS-granting	10	16	25	–
	Public	69%	71%	83%	61%
	Private	31	29	17	39
Source of support	Teaching assistantship	32%	56%	34%	8%
	Research assistantship	47	15	**21	73
	Fellowship	8	10	3	8
	Employment (full-time)	6	10	34	2
	Family, savings, loan	3	5	6	1
	Other	4	4	2	8

* *These data were derived from the survey of Enrollments and Degrees.*
** *Includes 8% military.*

eign graduate students. Another factor contributing to the low percentage of women among the advanced graduate students is that they are more likely to terminate their studies at the master's level.

Since foreign graduate students have more than doubled during the decade of the 1980s, it seems appropriate to focus special attention on this group. Their current proportions are shown under "citizenship" in **Table I**, which does not elaborate on their geographic distribution among the nine regions of the United States. In seven of those nine regions, their representation is almost identical to that of the U.S. students. However, the Pacific and the Mid-Atlantic regions are the exceptions. Although the largest contingent of foreign students come from Pacific-rim countries, they are underrepresented in the Pacific region where graduate physics programs enrolled 22% of the U.S. students compared to 14% of the foreign students. By contrast, the universities of the Mid-Atlantic region enrolled 21% of the foreign students compared with 15% of the U.S. students.

The fourth characteristic in **Table I** illustrates that the influx into physics from other disciplines is generally small. Engineering graduates always form the largest group among the transfer students and they comprised only 7% of all first-year graduate students in 1988–89. To highlight attrition rates we compare the graduate enrollment at public with that at private institutions; on that basis we find a considerably lower attrition at the private institutions which enroll 29% of the first-year students and confer 39% of all physics doctorates.

The sources of support listed as the last characteristic of **Table I** indicate the gradual transfer from teaching assistantships, offered to a majority of the entering graduate students, to research assistantships for which the more advanced students qualify. Over 500 graduate students are enrolled in evening programs that are aimed primarily at the master's degree. These students study on a part-time basis and hold full-time off-campus positions where their employers encourage them to seek additional training.

By making a firm distinction between U.S. and foreign graduate students who identify themselves as members of one of the six minority groups presented in **Table II**, we can monitor changing characteristics of any particular group with respect to time. For example, the 146 responding U.S. Orientals represent a 50% increase over their number recorded in 1980; the doctorate recipients among them tripled in that same period of time. Comparisons among the minority groups are difficult because of the wide range in the number of respondents from each group. The 1989 version of **Table II** includes the characteristic "type of research" for the first time.

Table II. Characteristics of minority group physics students, 1988–89.

Characteristics		Black U.S.	Black Foreign	Native American Indian	Hispanic Puerto Rican	Hispanic Mexican American	Hispanic Other U.S.	Hispanic Other Foreign	Asian Indian U.S.	Asian Indian Foreign	Asian Oriental U.S.	Asian Oriental Foreign	Arab U.S.	Arab Foreign
	Total number:	68	35	15	16	17	52	100	32	340	146	1 721	16	119
Sex	Female	13	5	–	2	2	6	9	7	75	23	289	–	13
	Male	55	30	15	14	15	46	91	25	265	123	1 432	16	106
Candidacy for:	TMS	15	2	1	–	2	4	11	8	30	8	91	1	10
	MS and PhD	49	28	13	14	12	38	74	19	263	100	1 267	13	96
	PhD only	4	5	1	2	3	10	15	5	47	38	363	2	13
Student status	Full-time	61	35	13	14	16	45	96	30	332	133	1 683	14	114
	Part-time	7	–	2	2	1	7	4	2	8	13	38	2	5
Full-time equivalent years of graduate study	<1	23	4	6	4	6	13	17	13	42	33	203	3	12
	2	18	11	2	2	5	6	18	2	52	32	297	4	15
	3	17	3	1	4	–	5	17	6	54	21	323	1	19
	4	3	7	5	1	2	4	18	2	62	21	324	2	15
	5	2	3	–	2	3	11	10	3	49	21	279	1	19
	6	1	5	1	1	1	6	10	1	45	11	178	–	13
	>7	4	2	–	2	–	7	10	5	36	7	117	5	26
Major subfields	Biophysics	3	2	1	–	1	2	4	–	13	6	76	1	6
	Condensed matter	16	15	9	5	7	17	30	9	137	67	806	5	36
	Elect., atomic, molecular	2	1	1	–	1	3	7	1	26	10	127	1	17
	Elem. particles	1	3	–	1	2	11	16	3	40	14	159	–	13
	Math. physics	1	1	–	2	1	2	10	2	20	7	53	1	8
	Nuclear	8	3	–	1	–	2	9	9	27	13	103	–	11
	Optics	11	3	1	–	2	4	3	4	21	5	108	1	7
Type of research (adv. students)	Experimental	40	13	9	7	8	25	35	15	169	73	800	9	53
	Theoretical	8	12	3	3	5	16	53	9	101	34	406	3	35
Graduate degree recipients	Terminal masters	17	6	1	–	1	1	12	–	37	11	66	2	17
	Doctors	9	7	2	2	1	6	24	6	63	35	237	5	29

The data in **Table III** were scaled up to give an estimate of the total number of graduate physics students in each of the major subfields and at nine levels of graduate study. This type of analysis indicates which subfields are likely to require more time to complete a dissertation. Another function of **Table III** is to estimate the number of graduates in a given subfield who will seek employment within a year or two.

Table III. Number of graduate physics students, by subfield* and years of graduate study completed, 1988–89.

		Full-time equivalent years of graduate study									Total graduate students	
		< 1 yr.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	>9 yrs.	N	%
Distribution of students	N	3 132	2 765	2 200	1 920	1 650	1 055	350	150	139	13 361**	
	%	23.4	20.7	16.5	14.4	12.4	7.9	2.6	1.1	1.0		100%
Astrophysics		215	195	155	105	100	65	20	10	15	880	6.6
Bio/medical physics		130	110	75	70	55	30	15	5	5	495	3.7
Condensed matter		910	900	735	790	685	370	120	50	50	4 610	34.5
Electron, atomic, molecular		250	200	205	135	120	85	30	15	15	1 055	7.9
Elementary particles		340	260	260	245	230	180	65	15	10	1 605	12.0
Mathematical physics		180	185	110	95	95	60	15	5	5	750	5.6
Nuclear physics		230	215	205	155	145	80	25	15	10	1 080	8.1
Optics/lasers		240	225	140	105	65	40	25	10	5	855	6.4
Plasmas/fluids/chaos		145	125	110	100	70	75	20	15	10	670	5.0
Physics applications		165	145	95	40	30	15	5	5	5	505	3.8
Other subfields		327	205	110	80	55	55	10	5	9	856	6.4

* *The distribution of students in each subfield is based on 7184 respondents to this question.*
** *The total was derived from the survey of Enrollments and Degrees.*

Table IV. Sources of support for graduate physics students, by type of institution and citizenship, 1988–89.

		Doctor's-granting institutions		Master's-granting institutions	
		U.S. students	Foreign students	U.S. students	Foreign students
Teaching assistantship		27%	35%	35%	60%
Research assistantship		49	52	11	23
Fellowship		11	5	3	4
Foreign government		–	3	–	2
Family, savings, loans		3	3	8	8
Full-time employment		7	–	35	3
Other*		3	2	8	–
		100%	100%	100%	100%
Estimated distribution of all graduate students	N**	7 020	5 049	821	471
	%	52	38	6	4

** Other includes the military and part-time employment.*
*** These data were derived from Table VIII in the survey of Enrollments and Degrees.*

By separating the graduate enrollment for the two types of institutions and dividing it on the basis of citizenship, a very different picture emerges for the sources of support than that shown in **Table I**. For example, full-time employment supports the graduate training of some 800 U.S. students, leaving foreign students to rely more heavily on teaching assistantships. Also presented in **Table IV** is the distribution of fellowships, many of which are federally funded,and are therefore more likely to be offered to U.S. citizens. But most importantly, the new format of **Table IV** was designed to answer the frequent question concerning the support for that growing number of foreign graduate students. The table clearly shows that both teaching and research assistantships support between 80% and 90% of the foreign students irrespective of the type of graduate program they enrolled in.

Given the emphasis physicists place on the intensive professional work that ultimately leads to a dissertation, we singled out the doctoral candidates, grouped them by type of research within each subfield and present this array in the form of **Table V**. The last two rows of this table show that the ratio of experimentalists to theoreticians remains at 2:1.

Table V. Number* of advanced graduate physics students specializing in selected experimental or theoretical subfields by years of graduate study completed, 1988–89.

Physics subfield	Type of research	Full-time equivalent years of graduate study							Total		
		3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	>9 yrs.	N	% Exp.	% Theo.
Astrophysics	experimental	79	64	37	36	13	7	5	241	4.8	
	theoretical	83	41	61	30	6	2	10	233		9.5
Bio/medical	experimental	70	60	46	23	10	5	1	215	4.3	
Condensed matter	experimental	542	559	498	271	96	44	40	2 050	40.9	
	theoretical	187	223	170	84	21	9	8	702		28.6
Electron, atomic, molecular	experimental	146	92	86	67	23	9	13	436	8.7	
	theoretical	53	46	31	19	5	3	3	160		6.5
Elem. particles	experimental	194	148	129	133	49	10	13	676	13.5	
	theoretical	69	83	94	48	12	3	–	309		12.6
Math. physics	theoretical	107	94	96	58	12	9	4	380		15.5
Nuclear	experimental	155	108	96	55	14	12	11	451	9.0	
	theoretical	52	48	48	22	9	2	–	181		7.4
Optics/lasers	experimental	116	79	65	42	15	6	3	326	6.5	
Plasmas/ fluids/chaos	experimental	67	51	31	40	9	4	3	205	4.1	
	theoretical	46	50	37	39	10	10	7	199		8.1
Physics applications	experimental	63	51	38	21	5	3	4	185	3.7	
Other subfields	experimental	60	44	41	38	25	8	9	225	4.5	
	theoretical	111	79	46	29	16	4	5	290		11.8
Total	experimental	1 492	1 256	1 067	726	259	108	102	5 010	100.0%	
	theoretical	708	664	583	329	91	42	37	2 454		100.0%

** The numbers in this table have been scaled up to reflect the total number of graduate students (7 464) who completed three or more years of graduate study.*

Table VI. Distribution by subfield and employment offers for doctorate recipients, 1988–89.

Physics subfield		Total in subfield	New 'postdocs' in the U.S.	Employment-oriented graduates in the U.S.	Percentage of graduates seeking potentially permanent employment in the United States received: 0 offers	1 offer	>2 offers
Astrophysics		7.8%	4.3%	3.4%	–	58%	42%
Biophysics		3.1	2.2	0.9	14%	29	57
Chemical physics		2.8	1.9	1.3	–	14	86
Condensed matter		34.2	24.1	10.3	13	44	43
Electron, atomic, molecular		6.4	4.7	2.1	8	75	17
Elementary particles		15.3	13.1	3.0	9	55	36
Mathematical physics		6.1	4.1	1.7	–	70	30
Nuclear		8.3	6.0	2.4	12	41	47
Optics/lasers		5.6	2.8	3.2	6	39	55
Plasmas/fluids/chaos		4.8	3.7	1.7	–	56	44
All other subfields		5.6	1.1	2.0	–	21	79
Total	%	100.0%	68.0%	32.0%	7%	45%	48%
	N	1 112	673*	316*			
All experimental subfields		63%	400	218	5%	42%	53%
All theoretical subfields		37%	273	98	11%	51%	38%

**An estimated 123 doctoral graduates, not part of the employment analysis, include 109 who leave the U.S. and 14 whose plans are described as "Other" in Figure III.*
Note: The "job offer" portion of this table does not include graduates with commitments to foreign employers.

Degree recipients

Upon completing a doctorate, the graduate has achieved a high degree of specialization that normally has a strong bearing on the choice between two types of employment. They are a postdoctoral fellowship or a potentially permanent position and both the physics subfield and the research method are influential in deciding between them. Foreign graduates are generally limited to postdoctoral fellowships because U.S. immigration laws permit only temporary employment on a student visa for work that is directly related to the specialty; the assumption the immigration service makes is that highly technical employment is not available in the graduate's native country. **Table VI** divides the dissertation subfields into ten major areas of concentration and, as its first column of data, presents the distribution of all 1,112 doctorate recipients. The central portion of **Table VI** focuses on the estimated 990 doctoral graduates who remained in the United States and reported their choices between the two types of initial employment defined above. The third part of this table singles out the subgroup interested in permanent positions and relates the job offers they received to the subfields of their dissertations.

In connection with **Figure I** we mentioned the employers' preferences for experimentalists; the last two rows of **Table VI**, which compare collectively the job offers for the experimentalists with those for the theoreticians, substantiate this statement. Not only is the proportion of experimentalists who report no offers at the time of the survey considerably lower than the one reported by the theoreticians (5% compared with 11%), but also a larger proportion of experimentalists than theoreticians received multiple offers to choose from. Although the number of theoreticians (98) has not changed significantly from the previous year, a greater number of them received multiple offers in 1989.

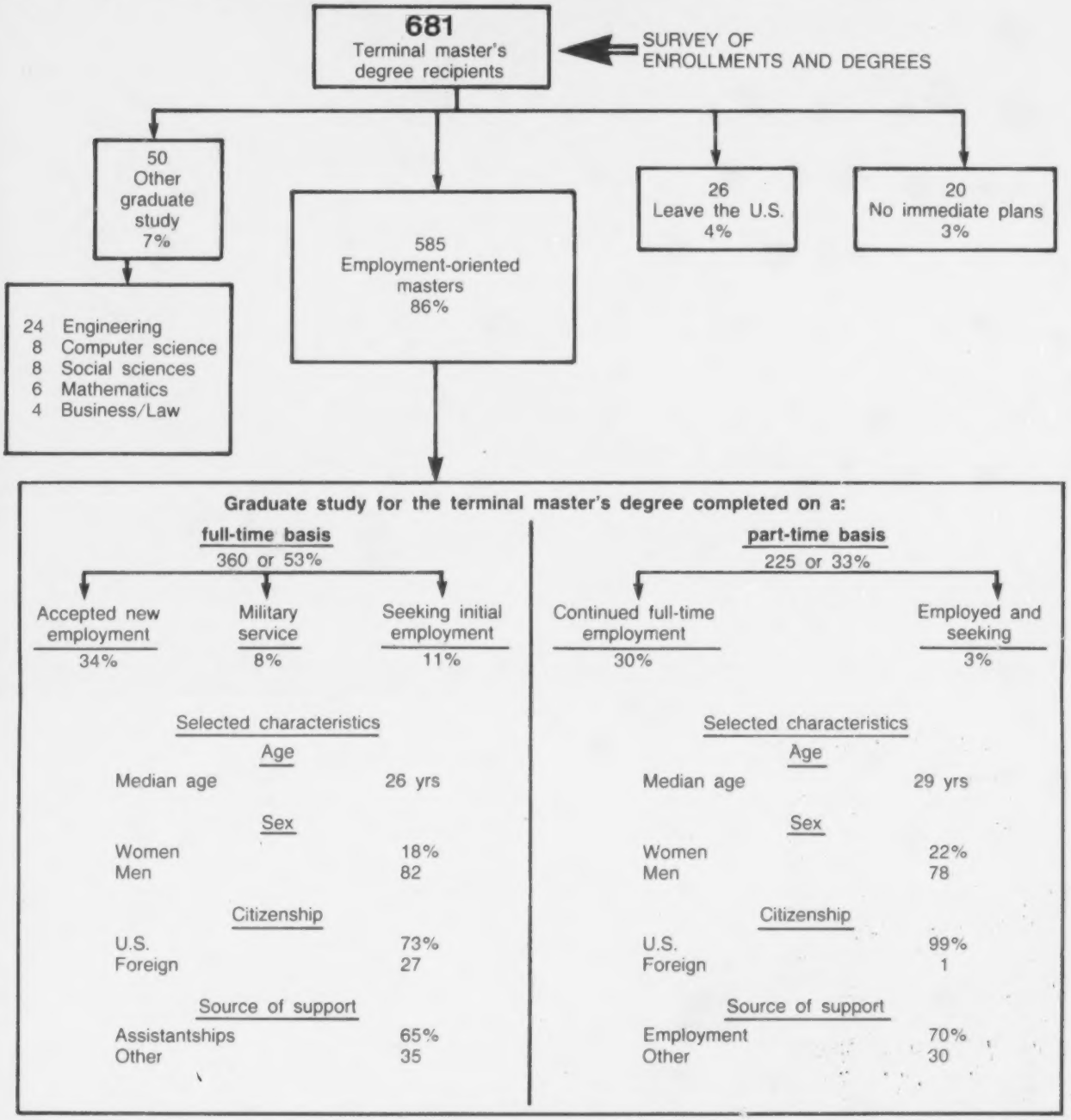
Because projections of the demand for physicists in the U.S. vary so greatly, the initial employment of that large contingent of foreign doctorate recipients became the focus of many questions. The revised format of **Table VII** clearly indicates how many foreign graduates remain in the U.S. for some period of time after completing their doctorates, and what type of employment they are offered. For example, the percentage of foreign citizens who secured potentially permanent positions in the U.S. (13%) has not changed between 1988 and 1989. Among the U.S. doctoral graduates a slight shift from potentially permanent employment toward postdocs occurred.

Table VII. Employment of doctoral graduates by citizenship, 1988–89.

Doctoral graduates		U.S. employer 'Postdoc'	U.S. employer Accepted	U.S. employer Cont.	Foreign employer 'Postdoc'	Foreign employer Accepted	Uncommitted in the U.S.	%	Total No. of resp.	%
U.S. citizens		55%	31%	5%	4%	1%	4%	100%	426	61%
Foreign citizens		61	11	2	5	13	8	100	273	39
Total	N	403	160	29	28	41	38		699	
	%	58	23	4	4	6	5	100%		

Note: Six graduates had no immediate plans and three foreign graduates reported "other graduate study."

Figure II. Post-degree plans of physics terminal master's degree recipients, 1988–89.



The bachelor's degree rarely affords the opportunity to concentrate on one of the physics subfields; nevertheless some level of graduate training is considered beneficial when the initial employment is physics-related. To meet the requirements that a position in applied research calls for, over one thousand students, each year, enter graduate physics programs that lead to a terminal master's degree. Unlike a doctoral program, which commits a student to approximately six years of graduate work, the master's degree offers considerable flexibility in terms of course-work and a dissertation. The two years of full-time training can be performed on a part-time basis spread out over five years or longer, and at many universities the dissertation is optional.

Table VIII. Distribution of terminal masters by subfield and use of physics training, 1988–89.

Physics subfield	Total in subfield*	Post-degree use of subject matter reported by masters employed in the U.S.		
		extensive	little	none
Astrophysics	7%	70%	20%	10%
Condensed matter	22	61	32	7
Electron, atomic, molecular	8	45	55	–
Nuclear physics	8	40	53	7
Optics/lasers	12	55	35	10
Physics applications	11	23	69	8
Cross-disciplines	7	45	55	–
All other subfields	25	69	28	3
Total	100%	54%	40%	6%

** Based on 275 respondents.*

Figure II highlights the class of 1989 both in terms of the approaches the students used to acquire the master's degree as well as the different options these graduates pursued after becoming physics masters. Only an estimated 7% of them used that physics training as background for further studies in another discipline. The large employment-oriented group includes over 200 masters who continued the full-time employment that supported them through graduate school. One in five of the graduates who completed their terminal master's degrees on a full-time basis experienced some difficulty in finding initial employment. The characteristics of the two major groups differ significantly as illustrated in **Figure II**. For example, the former full-time graduate students were younger, included somewhat fewer women but substantially more foreign citizens and assistantships from the physics departments supported two-thirds of them.

Although the writing of a dissertation for a master's degree tends to be optional, almost all our respondents identified a subfield they concentrated on during their graduate studies. **Table VIII** shows the extent to which the masters utilized their specialties in post-degree employment. Among the terminal masters who specialized in a "physics application," only one in four reported extensive use of that subfield.

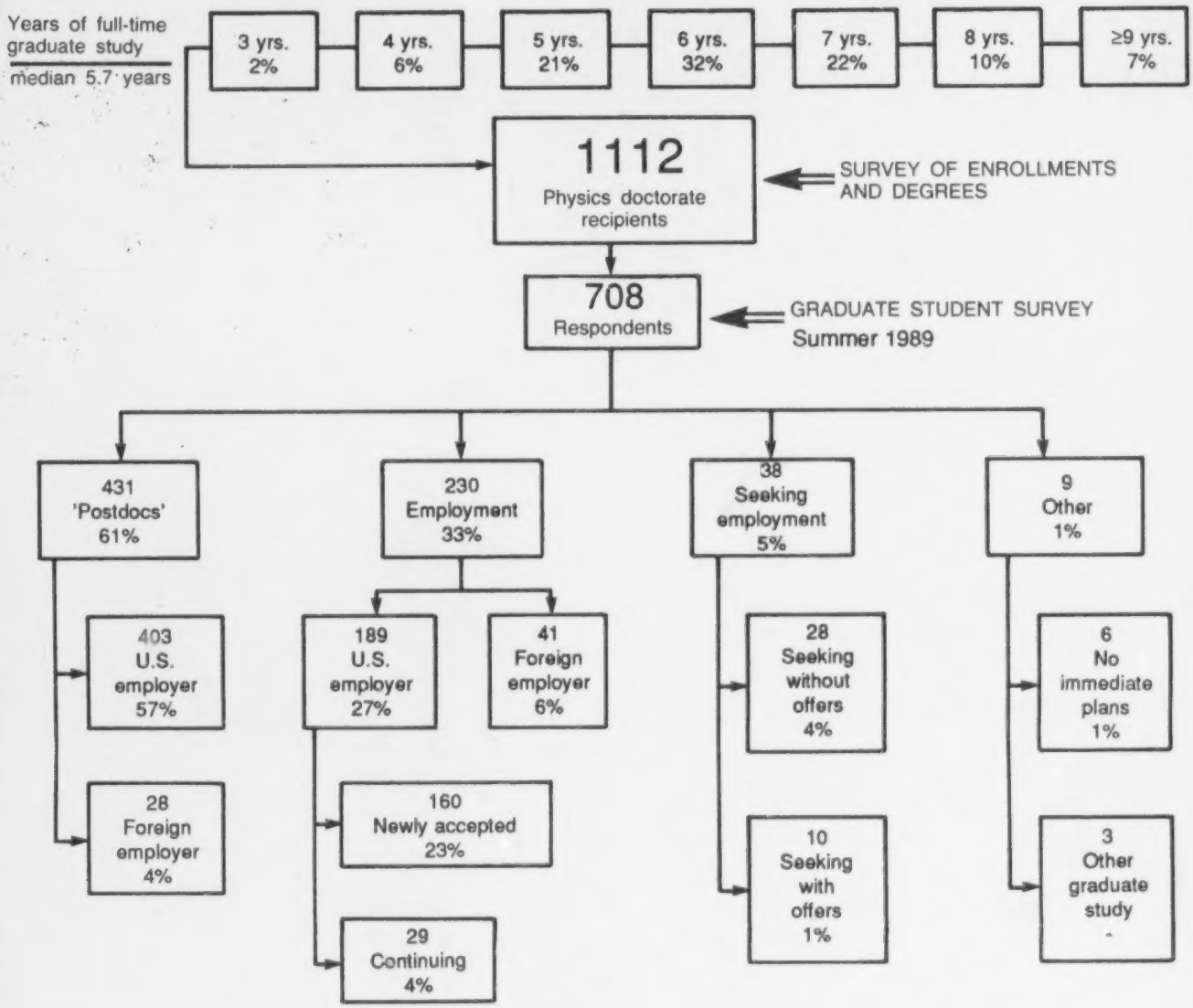
At the master's level, the new physicists are well equipped to perform applied research, development or engineering tasks. The major employers who utilize those capabilities are industry and the government. Management training and other types of nonphysics professional work were reported by fewer than 10% of the respondents according to the data in **Table IX**. The physics masters who identified a university as their type of employer described their positions as temporary.

Table IX. Employment characteristics of 1988–89 recipients of physics master's degrees.

Work activity	Type of employer							Total	
	University	College	Secondary school	Industry	Government	Military service	Non-profit organization	N	%
Teaching	10	20	16	–	6	9	–	61	12
Research	8	–	–	20	16	3	4	51	10
Res. and dev.	16	–	–	130	20	9	4	179	37
Engineering	5	–	–	107	8	10	–	130	27
Comp. science	6	–	–	16	5	1	–	28	6
Management	2	–	–	–	–	13	–	15	3
Nonphysics prof'l	–	–	–	12	4	10	–	26	5
Total N	47	20	16	285	59	55	8	490	
%	10	4	3	58	12	11	2		100%

Note: The data in this table reflect the employment information contributed by individual degree recipients as well as department chairpersons.

Figure III. Post-degree plans of physics doctorate recipients, 1988–89.



The requirements for a physics doctorate are such that only graduate study on a full-time basis constitutes a practical approach to such a goal. From the top of **Figure III** we learn that one-third of those 1112 degree recipients in the class of 1989 spent at least seven years to complete all the requirements for their PhDs. This figure elaborates on the data presented in **Table VII** by relating the doctoral respondents to the total population and including additional details on graduates who had not yet accepted employment.

Table X. Use of physics in potentially permanent employment for graduate degree recipients, 1988–89.

	Major employer	Extensive use of physics training with respect to: Method	Subject matter	Number responding to question
Doctorate recipients	Univ./coll.	82%	90%	42
	Industry	84	65	68
	Fed. funded res. ctr.	95	63	19
	Government	83	67	12
	All employers	85%	73%	148

		Use of physics training with respect to subject matter: Extensive	Little	None	Number responding to question
Terminal masters	Educational inst.	74%	26%	–	19
	Industry	56	33	11%	66
	Fed. funded res. ctr./Gov't.	37	59	4	51
	All employers	51%	42%	7%	136

When accepting potentially permanent employment, both masters and doctorate recipients share a concern about utilizing their specialized knowledge, but view it differently. To the doctoral graduates it is as important to use the research methods they developed, as the subfield in which they became experts. The masters, who spent less time in graduate school, are primarily concerned with the extent to which they utilize the subject matter of their area of concentration. The two parts of **Table X** summarize the responses from 148 doctoral physicists and 136 physics masters. The major types of employers are listed for both groups and a comparison confirms that for each type of employer more doctoral physicists than terminal masters are making extensive use of the subject matter of their respective subfields. In comparing these data with those of the previous year, a larger proportion of masters (51% compared with 41%) are making extensive use of their specialties. This shift must be attributed to the masters in the military whose assignments appear to have become increasingly technical.

Having shown in **Table VII** that 189 doctoral graduates found potentially permanent employment in the U.S., we offer additional details on that employment in **Table XI**. All but six graduates specified both their types of employers and their work activities. Notable changes from the previous year include a shift away from research and toward development and engineering work as the industrial employers gain four percentage-points.

Table XI. Employment with potential permanence in the U.S. for 1988–89 physics doctorate recipients.

Work activity		Type of employer: University	College	Industry	Fed. funded res. ctr.	Government	Non-profit organization	Total N	Total %
Teaching		6	11	–	–	–	–	17	9
Research		8	–	16	12	6	2	44	24
Res. and teaching		13	9	–	–	1	–	23	13
Res. and dev.		3	–	54	6	8	2	73	40
Engineering		–	–	9	1	3	–	13	7
Consulting		–	–	3	2	–	–	5	3
Nonphysics professional		–	–	3	–	2	3	8	4
Total	N	30	20	84	22	20	7	183	
	%	16	11	46	12	11	4		100%

Table XII. Median monthly starting salaries paid by U.S. employers to new physics degree recipients, 1989.

Type of Employer	Bachelor's degree recipients		Terminal master's degree recipients		Doctorate recipients			
	Percentage accepting positions	Monthly starting salaries	Percentage accepting positions	Monthly starting salaries	Percentage accepting: 'Postdocs'	Potentially perm. pos.	Monthly starting sal. for: 'Postdocs'	Potentially perm. pos.
Secondary school	5%	$1570	3%	$2350	–	–	–	–
College	1	*	4	*	–	3%	–	$2450
University	4	1670	10	*	46%	5	$2280	2750
Industry	49	2250	58	2670	6	15	3500	4080
Gov't. inc. mil.	37	1770	21	2300	7	3	2680	3200
Fed. funded res. ctr.	2	*	2	2425	9	3	2510	3700
Other	2	*	2	*	1	2	2250	2400
All employers	100%	$1960	100%	$2600	100%		$2310	$3540

**Insufficient data.*

Starting salaries presented in **Table XII** include only those paid by U.S. employers for newly accepted positions. For purposes of comparison we have added the starting salaries of physics bachelors. The doctoral physicists are divided into two groups because those who accepted potentially permanent employment are paid significantly higher salaries than the graduates who start out as postdoctoral fellows. In recent years the median salary of postdocs has risen rapidly as indicated by the fact that until 1986 their median had been consistently lower than the bachelors' median salary. The median starting salary for masters shows no change from the previous year and industry continues to pay the highest salaries in each of the degree categories. Other changes from the previous year, concerning postdocs, include a four percentage-point shift away from the universities while corresponding gains were recorded for industry and the government laboratories. The median salary for offers with potential permanence, $3540, reflects a 4% increase over the 1988 salary.

ASTRONOMY

Almost 90% of the graduate astronomy students are enrolled in separate astronomy departments and their numbers are increasing. Also, as contributors to this survey, the graduate astronomy students are our best respondents. Attrition among them tends to be low as indicated by the data on student distributions presented in **Table XIII**. This table links the astronomy subfields to the levels of graduate study.

Table XIII. Graduate astronomy students* by subfield and years of graduate study, 1988–89.

		Full-time equivalent years of graduate study						Total	
		≤1 yr.	2 yrs.	3 yrs.	4. yrs.	5 yrs.	>6 yrs.	N	%
Distribution of students	N	169	148	133	117	94	119	780	
	%	22%	19%	17%	15%	12%	15%		100%
Astronomy subfields									
Astronomical instruments and techniques		8%	5%	4%	6%	3%	4%	41	5%
Cosmology, extragalactic objects, quasi-stellar objects		22	20	27	26	41	17	190	24
Galactic structure, stellar motions		8	6	16	5	2	5	55	7
Interstellar matter and gaseous nebulae		13	15	13	17	19	24	127	16
Solar system, space astronomy of the solar system		6	6	5	8	5	11	53	7
Stellar atmospheres and spectra, stellar evolution, solar and stellar interiors		10	18	18	19	22	21	137	18
Supernovae, X, γ and cosmic rays, pulsars		5	4	6	6	2	6	38	5
The sun		1	4	1	1	2	1	14	2
Astrophysics		12	11	6	6	2	7	62	8
All other subfields combined		15	11	4	6	2	4	63	8
		100%	100%	100%	100%	100%	100%		

** The percentages shown in this table are based on 547 respondents to the Graduate Student Survey. Astronomy department chairpersons reported a total of 780 graduate students for the survey of Enrollments and Degrees.*

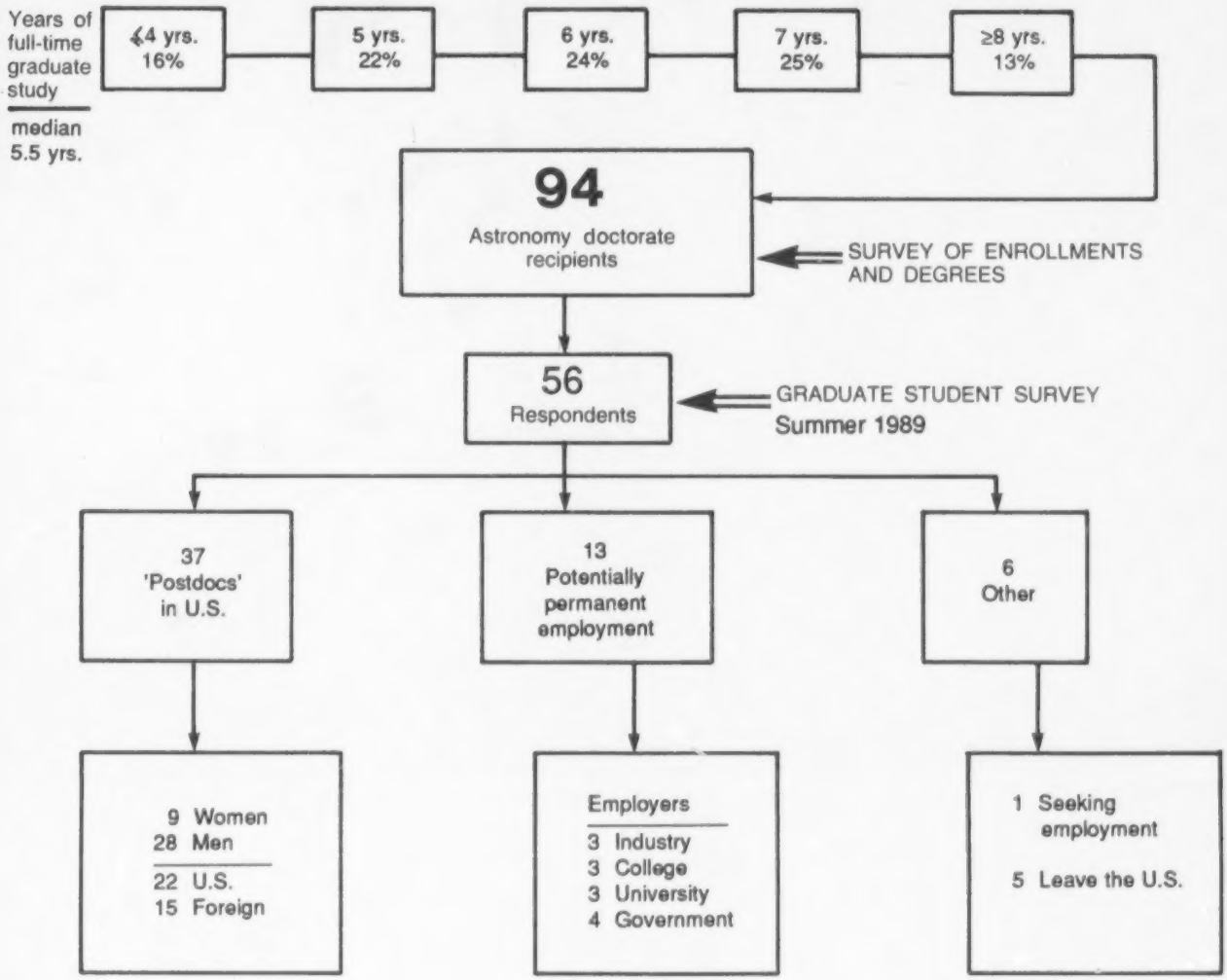
Table XIV. Characteristics of the graduate astronomy student population, 1988–89.

Characteristics		First-year graduate students	All graduate students	Doctorate recipients
	*Total population:	169	780	94
	Number of respondents:	107	547	56
Sex	Female	20%	19%	*17%
	Male	80	81	83
Citizenship	U.S.	74%	*77%	68%
	Foreign	26	23	32
High school physics	Yes	94%	93%	96%
	No	6	7	4
Major of bachelor's degree	Astronomy	29%	33%	27%
	Physics	64	56	55
	Engineering	1	4	5
	Mathematics	5	3	4
	Other	1	4	9
Type of bachelor's institution	PhD-granting	64%	56%	58%
	MS-granting	2	3	3
	BS/BA-granting	12	15	8
	Foreign	22	26	31
Type of graduate institution*	PhD-granting	94%	96%	100%
	MS-granting	6	4	–
	Public	67%	76%	80%
	Private	33	24	20
Source of support	Teaching assistantship	50%	26%	7%
	Research assistantship	19	49	75
	Fellowship	25	17	10
	Family, savings, loan	2	2	–
	Foreign government	–	1	5
	Other	4	5	3
Major subfields	Cosmology	22%	26%	27%
	Interstellar matter	14	16	22
	Solar system	6	7	11
	Stellar atmos. & spectra	11	19	23
	Astrophysics	12	8	4

** These data were reported by astronomy department chairpersons as part of the survey of Enrollments and Degrees.*
Note: Only sixteen students were granted terminal master's degrees in 1988–89, six of whom responded to this survey.

For purposes of comparison, we adopt the format of **Table I** for **Table XIV** and present eight characteristics of the graduate astronomy students. Comparing similar subgroups with the total enrollment, we find that the higher proportion of women included among the astronomers also indicate a lower attrition rate than do the women who are physics students. Other differences point to a lower proportion of foreign students, a large influx of physics students because so few astronomy bachelor's degree programs are available, and a significantly higher proportion of beginning graduate students who hold fellowships.

Figure IV. Characteristics and post-doctorate status of 1988–89 astronomy graduates.



The relative sizes of the two groups make a comparison of the astronomy and physics doctorate recipients less meaningful; nevertheless, **Figure IV** approximates the format of **Figure III**. Following historical patterns, a majority of the new astronomers accepted postdocs in 1989 which included 15 of the 18 foreign graduates. Salaries offered to new astronomers are considerably lower than those offered to physicists. Only nine of the thirteen graduates, who were offered potentially permanent positions, reported their salaries, the median of which was $2500.

This report was prepared with the help of Thomas N. Stovall.